

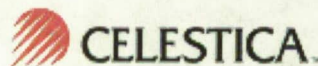
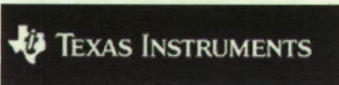
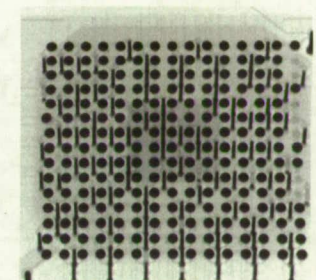
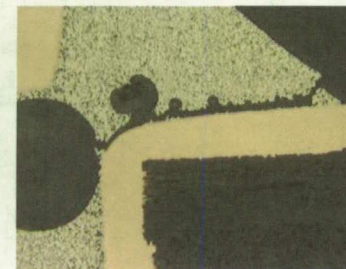
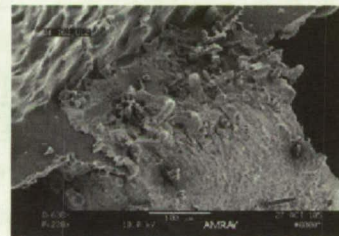
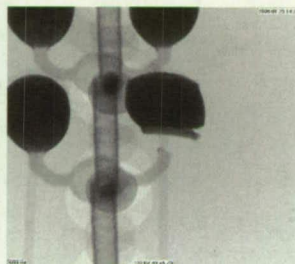
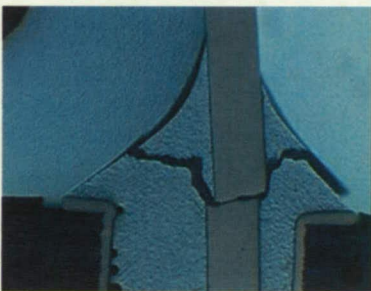
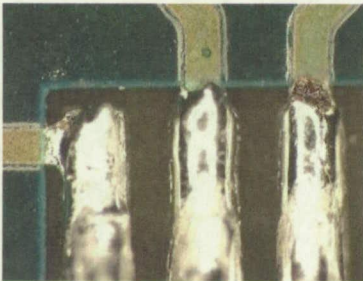
NASA-DoD Lead-Free Electronics Project

DoD Soldering Technologies Working Group (STWG)

April 14 – 15, 2009



ITB Inc.



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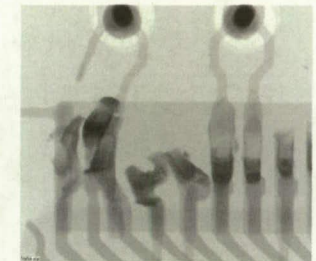
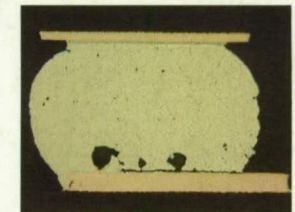
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Testing project will build on the results from the JCAA/JGPP LFS Project

The primary technical objective of this project is to undertake comprehensive testing to generate information on failure modes/criteria to better understand the reliability of:

Packages (e.g., Thin Small Outline Package [TSOP], Ball Grid Array [BGA], Plastic Dual In-line Package [PDIP]) assembled and reworked with lead-free alloys

Packages (e.g., TSOP, BGA, PDIP) assembled and reworked with mixed (lead/lead-free) alloys.

Web Links:

NASA-DoD Lead-Free Electronics Project:

http://www.teerm.nasa.gov/projects/NASA_DODLeadFreeElectronics_Proj2.html

JCAA/JGPP Lead-Free Solder Project

http://www.teerm.nasa.gov/projects/LeadFreeSolderTestingForHighReliability_Proj1.html

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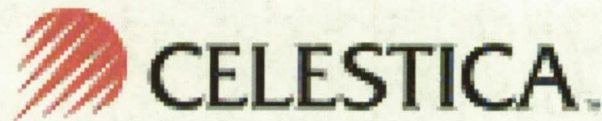
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Lead-Free Solder Alloys

- SAC305 (Sn3.0Ag0.5Cu)

- Surface mount assembly

This alloy was chosen for reflow soldering because this particular solder alloy has shown the most promise as a primary replacement for tin-lead solder. The team decided that they wanted to select at least one “general purpose” alloy to be evaluated and it was determined that the SnAgCu solder alloy would best serve this purpose.

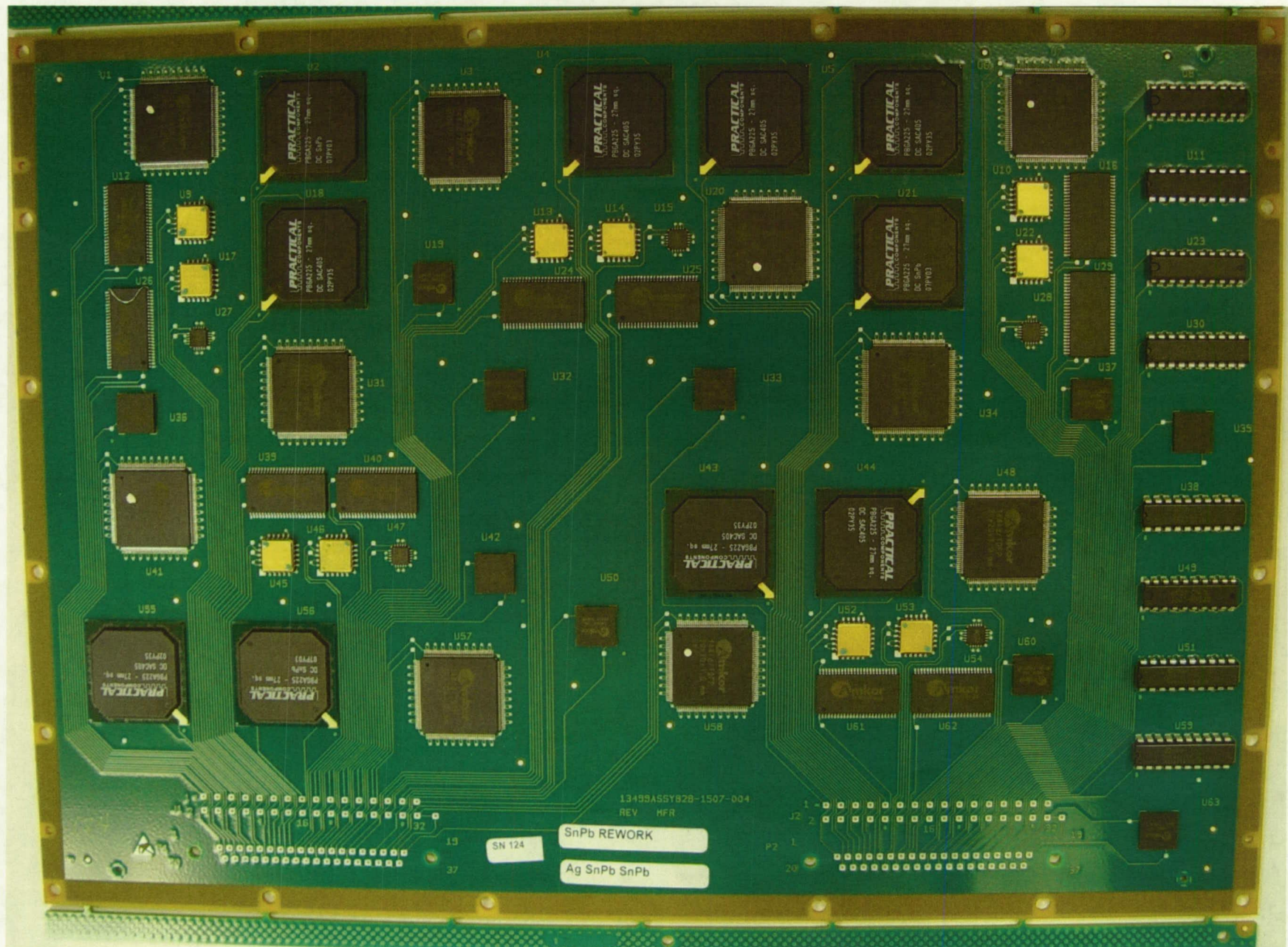
- SN100C (Sn0.7Cu0.05Ni+Ge)

- Plated through hole

- Surface mount assembly

This alloy is commercially available and the general trend in industry has been switching to the nickel stabilized tin-copper alloy over standard tin-copper due to superior performance. In addition, this nickel-stabilized alloy does not require special solder pots and has shown no joint failures in specimens with over 4 years of service.

193 Test Vehicles Assembled



Component Finish/Solder Combinations Example

SnPb Manufactured Test Vehicles				
Component	Component Finish	Reflow Solder	Wave Solder	Board Finish
BGA-225	SAC405	SnPb		Immersion Silver
BGA-225	SnPb	SnPb		
CLCC-20	SAC305	SnPb		
CLCC-20	SnPb	SnPb		
CSP-100	SAC105	SnPb		
CSP-100	SnPb	SnPb		
PDIP-20	NiPdAu		SnPb	
PDIP-20	Sn		SnPb	
QFN	Matte Sn	SnPb		
TQFP-144	Matte Sn	SnPb		
TQFP-144	SnPb Dip	SnPb		
TSOP-50	SnBi	SnPb		
TSOP-50	SnPb	SnPb		

Profiles used during initial assembly

Reflow Profile = SnPb

Preheat = ~ 120 seconds @140-183°C

Solder joint peak temperature = 225°C

Time above reflow = 60-90 sec

Ramp Rate = 2-3 °C/sec

Wave Profile = SnPb

Solder Pot Temperature = 250°C

Preheat Board T = 101°C

Peak Temperature = 144°C

Speed: 110 cm/min

Component Finish/Solder Combinations Example

Lead-Free Manufactured Test Vehicles							
Component	Component Finish	Set A			Set B		
		Reflow Solder	Wave Solder	Board Finish	Reflow Solder	Wave Solder	Board Finish
BGA-225	SnPb	SAC305		Immersion Silver ----- A limited Number of Boards will be Built with ENIG	SN100C		Immersion Silver
BGA-225	SAC405	SAC305			SN100C		
CLCC-20	SnPb	SAC305			SN100C		
CLCC-20	SAC305	SAC305			SN100C		
CSP-100	SnPb	SAC305			SN100C		
CSP-100	SAC105	SAC305			SN100C		
PDIP-20	NiPdAu		SN100C			SN100C	
PDIP-20	Sn		SN100C			SN100C	
QFN	Matte Sn	SAC305			SN100C		
TQFP-144	SnPb Dip	SAC305			SN100C		
TQFP-144	Matte Sn	SAC305			SN100C		
TSOP-50	SnPb	SAC305			SN100C		
TSOP-50	SnBi	SAC305			SN100C		

Profiles used during initial assembly

Reflow Profile = SAC305

Preheat = 60-120 seconds @150-190°C

Peak temperature target = 243°C

Reflow:~20 seconds above 230°C

~30-90 seconds above 220°C

Wave Profile = SN100C

Solder Pot Temperature = 265°C

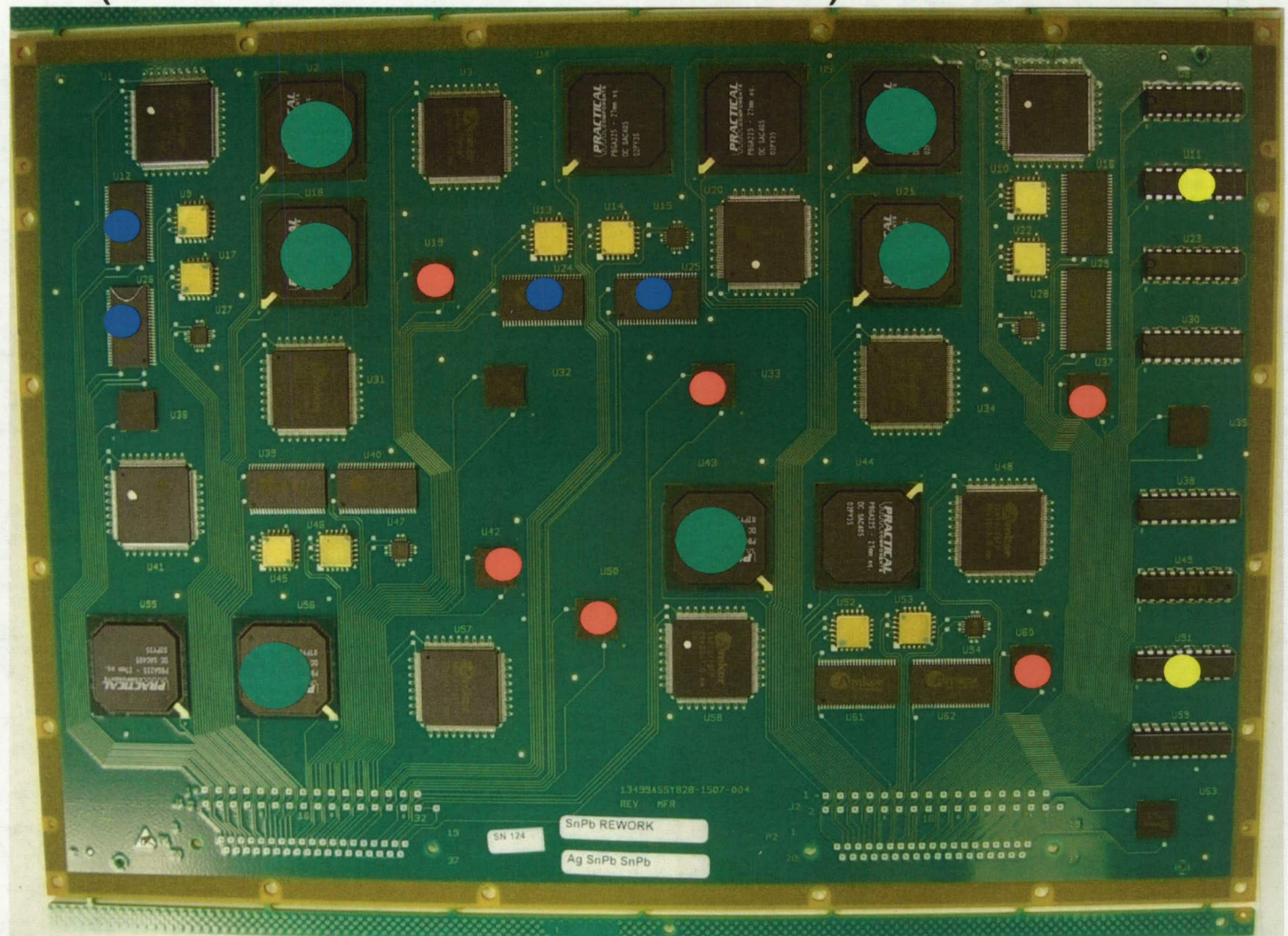
Preheat Board T = 134°C

Peak Temperature = 157°C

Speed: 90 cm/min

73 Test Vehicles Being Reworked (sub-set of the 193 assembled)

RefDes	Component
U18	BGA-225
U43	BGA-225
U06	BGA-225
U02	BGA-225
U21	BGA-225
U56	BGA-225
U33	CSP-100
U50	CSP-100
U19	CSP-100
U37	CSP-100
U42	CSP-100
U60	CSP-100
U11	PDIP-20
U51	PDIP-20
U12	TSOP-50
U25	TSOP-50
U24	TSOP-50
U26	TSOP-50



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Component Finish/Solder Combinations Example

SnPb Rework Test Vehicles						
Component	Original Component Finish	Reflow Solder	Wave Solder	New Component Finish	Rework Solder	Board Finish
BGA-225	SAC405	SnPb				Immersion Silver ----- A limited Number of Boards will be Built with ENIG
BGA-225	SnPb	SnPb		SAC405	SnPb	
BGA-225	SnPb	SnPb		SnPb	Flux Only	
CLCC-20	SAC305	SnPb				
CSP-100	SAC105	SnPb				
CSP-100	SnPb	SnPb		SnPb	Flux Only	
CSP-100	SnPb	SnPb		SAC105	SnPb	
PDIP-20	NiPdAu		SnPb			
PDIP-20	Sn		SnPb			
PDIP-20	SnPb		SnPb	Sn	SnPb	
QFN	Matte Sn	SnPb				
TQFP-144	NiPdAu	SnPb				
TQFP-144	SnPb Dip	SnPb				
TSOP-50	Sn	SnPb				
TSOP-50	SnBi	SnPb				
TSOP-50	SnPb	SnPb		SnPb	SnPb	
TSOP-50	SnPb	SnPb		Sn	SnPb	

Profiles used during initial assembly

Reflow Profile = SAC305

Preheat = 60-120 seconds @150-190°C

Peak temperature target = 243°C

Reflow: ~20 seconds above 230°C

~30-90 seconds above 220°C

Wave Profile = SN100C

Solder Pot Temperature = 265°C

Preheat Board T = 134°C

Peak Temperature = 157°C

Speed: 90 cm/min

Component Finish/Solder Combinations Example

Lead-Free Rework Test Vehicles						
Component	Component Finish	Reflow Solder	Wave Solder	New Component Finish	Rework Solder	Board Finish
BGA-225	SnPb	SAC305				Immersion Silver
BGA-225	SAC405	SAC305		SAC405	SnPb	
BGA-225	SAC405	SAC305		SAC405	Flux Only	
CLCC-20	SnPb	SAC305				
CSP-100	SnPb	SAC305				
CSP-100	SAC405	SAC305				
CSP-100	SAC105	SAC305		SAC105	Flux Only	
CSP-100	SAC105	SAC305		SAC105	SnPb	
PDIP-20	Sn		SN100C			
PDIP-20	Sn		SN100C	Sn	SN100C	
QFN	SnPb	SAC305				
TQFP-144	NiPdAu	SAC305				
TQFP-144	SAC 305 Dip	SAC305				
TSOP-50	SnBi	SAC305				
TSOP-50	SnPb	SAC305				
TSOP-50	Sn	SAC305		Sn	SnPb	
TSOP-50	SnBi	SAC305		SnBi	SAC305	

Profiles used during initial assembly

Reflow Profile = SAC305

Preheat = 60-120 seconds @150-190°C

Peak temperature target = 243°C

Reflow:~20 seconds above 230°C

~30-90 seconds above 220°C

Wave Profile = SN100C

Solder Pot Temperature = 265°C

Preheat Board T = 134°C

Peak Temperature = 157°C

Speed: 90 cm/min

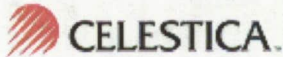
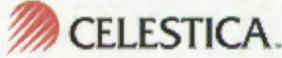
Rework Review / Discussion

- Trials and Tribulations of Rework
 - BGA and CSP rework, taking 1 ½ days per board
 - Lead-Free Rework, there have been problems with loss of continuity for some of the reworked BGA components. The problem is associated with lead-free BGA components reworked using flux only.
 - Attempts to reheat / reflow the components after initial rework were not successful. In some cases a second rework effort did not solve the problem.
 - The consortia decided that the limit for reworks will be 3. If the continuity issue is not solved after 3 reworks, the components will be left on the test vehicles non-functioning.

Testing Activities

Specific testing details can be found in the Joint Test Protocol (JTP)

<http://www.teerm.nasa.gov/reports.html>

Thermal Cycling: -20°C to +80°C 	Thermal Cycling: -55°C to +125°C 	Drop Testing 
Vibration 	Mechanical Shock 	Interconnect Stress Testing 
Combined Environments Testing 	Copper Dissolution  	

NAVSEA Crane Rework Effort

- Build 30 test vehicles (sub-set of the 193 assembled)
 - Test vehicles will be built with Lead-Free solder and Lead-Free component finishes only = similar to Manufactured test vehicles for Mechanical Shock, Vibration and Drop Testing
 - Lead-Free alloys, SAC305 and SN100C
 - Rework will be done using only SnPb solder
 - Perform multiple pass rework 1 to 2 times on random Pb-free DIP, TQFP-144, TSOP-50, LCC and QFN components
 - Testing
 - Thermal Cycling -55°C to +125°C
 - Vibration Testing
 - Drop Testing

Thermal Cycle -20/+80°C

Parameters	-	-20 to +80°C			
	-	Cycles: The project consortia will review the data and determine when the test is complete			
	-	Decision point 10,000 cycles			
	-	5 to 10°C/minute ramp			
	-	30 minute high temperature dwell			
	-	10 minute low temperature dwell			
					
Number of Test Vehicles Required					
Manufactured		Rework			
Mfg. SnPb	Mfg. LF	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF	
5	5	5	1	5	
Trials per Specimen		1			



Phase 1 = JCAA/JGPP Lead Free Solder Project Test Results

- **27,135 thermal cycles**
 - All of the ceramic leadless chip carriers (CLCC's) and TSOP's had failed
 - Most of the BGA's had failed (SnPb solder/SnPb balls; SAC solder/SAC balls; SACB solder/SAC balls; and mixed technologies)
 - Most of the TQFP-144's had failed

Combine Environments Testing

Parameters

-55°C to +125°C

Number of cycles ≥ 500

20°C/minute ramp

15 minute soak

Vibration for duration of thermal cycle

10 G_{rms}, initial

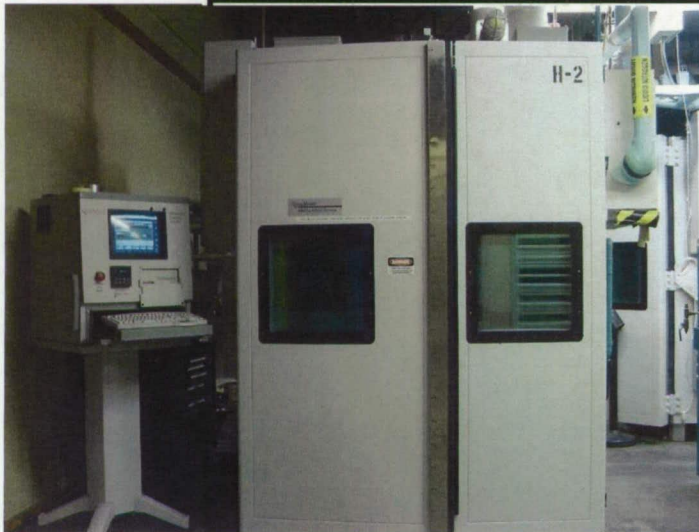
Increase 5 Grms after every 50 cycles

55 G_{rms}, maximum

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Number of Test Vehicles Required

Manufactured				Rework		
Mfg. SnPb	Mfg. LF	Mfg. LF SN100C	Mfg. LF ENIG	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	5	1	5	1	5
Trials per Specimens		1				



Status

- 500 cycles complete on 03/13/09
- Results
 - Only 14 of 150 CSPs have failed
 - Approximately 30% of components have failed
 - SnPb/SAC BGA-225s first component group to fail
- HALT chamber down 03/16 – 03/19
 - Repaired and ready for testing
- Test vehicles will continue combined environments testing, running at 55 grms
 - Will run 50 cycles and check status
- Testing re-start on 03/23/09
- Rework test vehicles are wired

Failure Map After 500 Cycles

Part	MFG SnPb					MFG SnAgCu					MFG Sn100C					
	20	21	22	23	24	69	70	71	72	73	116	117	118	119	120	
U2	188			314	150			330				181	234	122	307	
U5	437			122				54							213	
U21																
U44								196						234		
U56					271			242				166		146		
U4	128	255	158	104	96		492			174		20	468	100	153	
U6	130	234	142	40	77					188		330		114		
U18	116	164	89	97	111			247		169		49	345	94		
U43	94	147	160	120	27			213		110		380		150	172	
U55	114	106	133	157	86		363	157		68	227	202	369	2		
U10		322				414			293	429			366			
U14	325									306	293	400	314	332		
U17	479		424			365	292		344	457		484	225	200	458	
U45	465		392		450	340			443	227		264	492	72	323	
U52	361	394				312			281	212			324			
U9	252	294	484			282	243	322	344	327		360	332	306		
U13	383		288		285	256	290	238	282	302		433	259			
U22		232	370		388	446	371	218			228			244	256	
U46	334		322			317	486		374	241			464	211		
U53	472		387		378	438	372	302		424	243			413	323	
U19								461								
U36														233		
U37		493													476	
U42																
U60																
U32	434			423									350			
U33					319											
U35		194			401											
U50	394	495														
U63					463									492		
U11																
U30																
U38												344				
U51																
U8																
U23												446				
U49																
U59												460				
U15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
U27																
U28																
U47																
U54																
U3												494	428			
U31													255			
U34	0															
U48																
U57	1												444			
U1													384			
U7					343							434				
U20																
U41													316			
U58																
U16	344		113	362			208	278			276	315	192	246		
U24												202	194	328		
U26									201		209	250	150	272		

U15 = QFN component missing an I/O trace and is dead – all test vehicles

Test vehicles 20 – 24

- SnPb Manufactured Batch C
- SnPb Reflow and Wave solder
- SnPb profiles.

Test vehicles 69 – 73

- LF Manufactured Batch E
- LF Reflow (SAC305) / Wave (SN100C)
- LF profiles

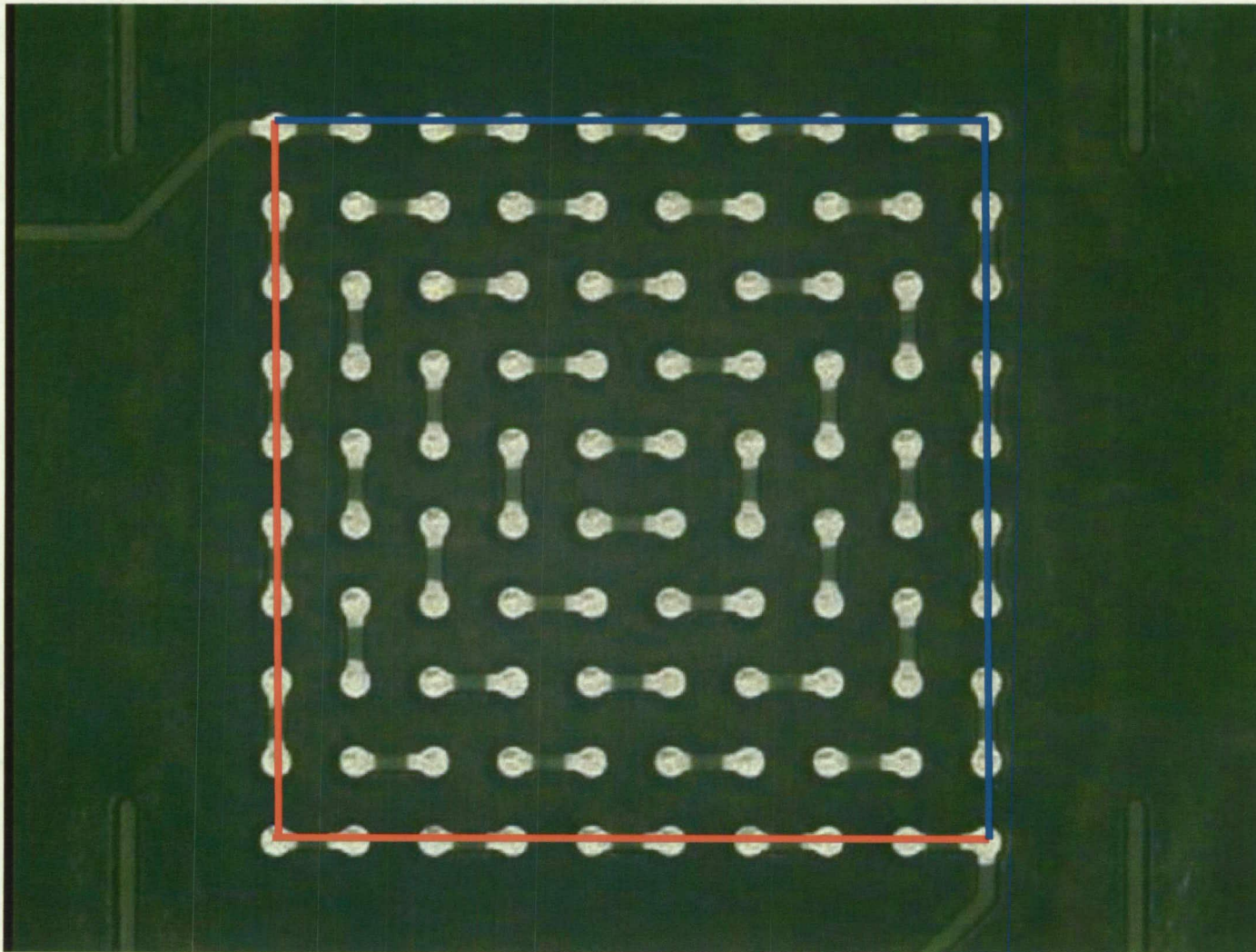
Test vehicles 116 – 120

- LF Manufactured Batch G
- LF Reflow (SN100C) / Wave (SN100C)
- LF profiles

Component Finish

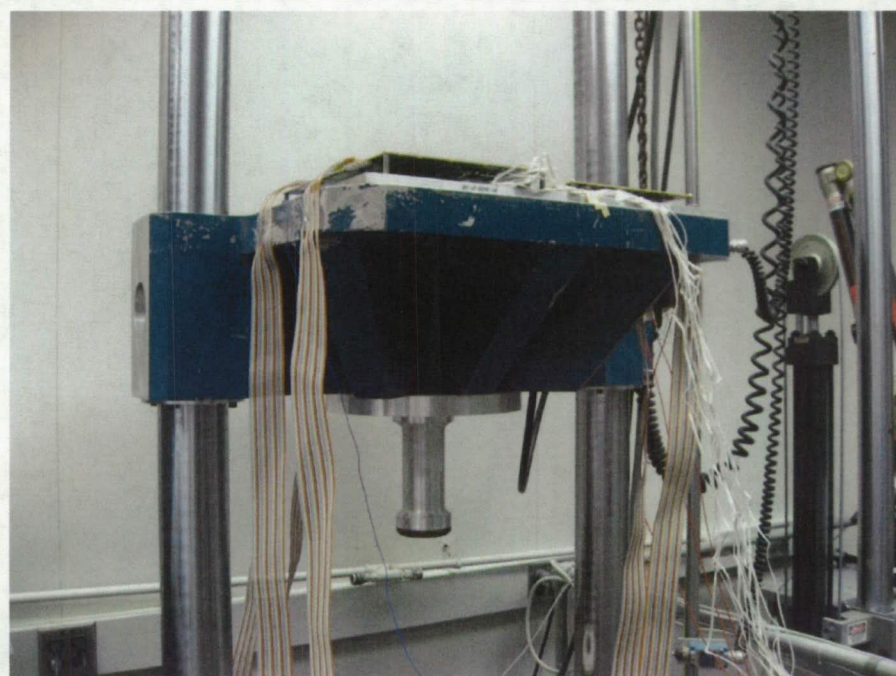
BGA	SnPb	SAC405
CLCC	SnPb	SAC305
CSP	SnPb	SAC105
TQFP	SnPb	Matte Sn
TSOP	SnPb	SnBi

When reviewing the CSP data, please note that the CSP components on all test vehicles only have continuity in the outside solder balls.

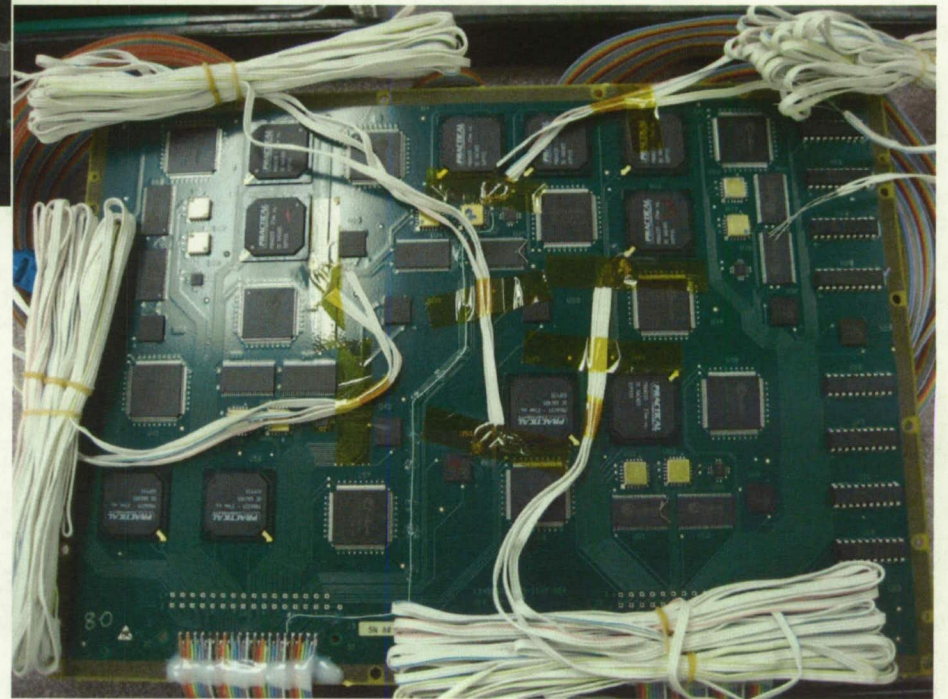
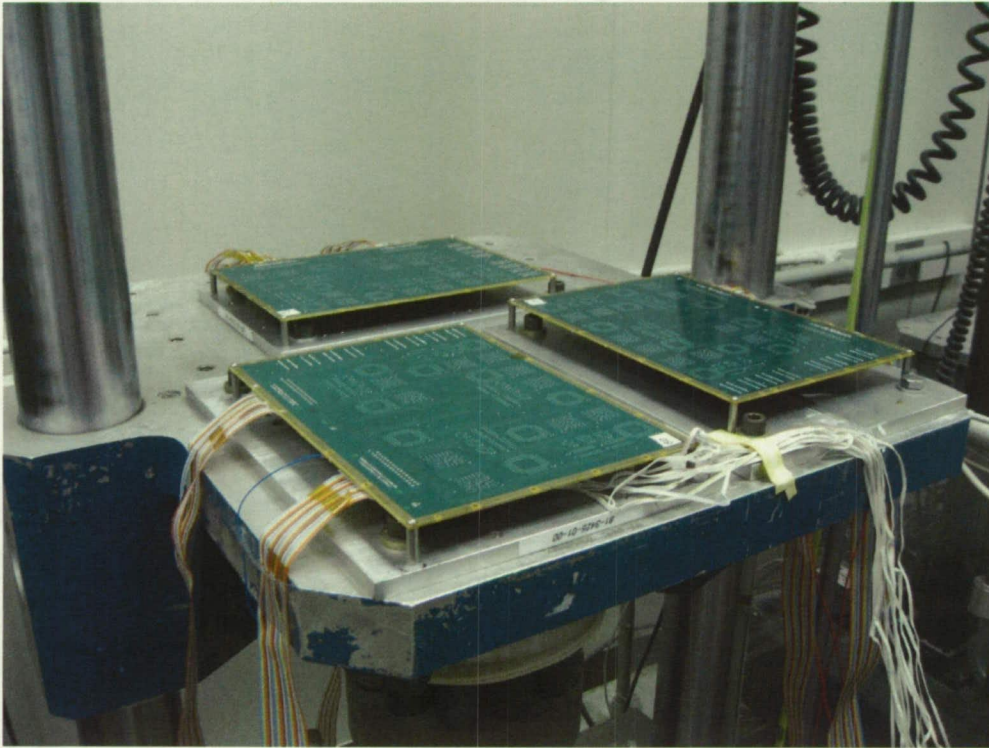


Drop Testing

Parameters	- Shock testing will be conducted in the -Z direction - 340Gpk input, 2ms pulse duration - Test vehicles will be dropped until all monitored components fail or 10 drops have been completed			
Number of Test Vehicles Required				
Manufactured		Rework		
Mfg. SnPb	Mfg. LF	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	5	1	5
Trials per Specimen		A maximum of 10 drops		



Drop Testing



NAVSEA Crane Rework Effort - Drop Test Vehicles

- Perform multiple pass rework 1 to 2 times on random Pb-free DIP, TQFP-144, TSOP-50, LCC and QFN components

RefDes	Part	Number of Reworks					
		Drop Test Board (Lead-Free Manufactured Batch F)					
		SN80	SN82	SN84	SN85	SN86	SN87
U16	TSOP 50/SnBi	2	2	2	1	2	1
U24	TSOP 50/SnBi	0	0	0	0	0	0
U26	TSOP 50/SnBi	0	0	0	1	0	1
U40	TSOP 50/SnBi	1	1	1	2	1	2
U62	TSOP 50/SnBi	1	1	1	0	1	0
U12	TSOP 50/Sn	0	0	0	0	0	0
U25	TSOP 50/Sn	2	2	2	1	2	1
U29	TSOP 50/Sn	1	1	1	2	1	2
U39	TSOP 50/Sn	0	0	0	1	0	1
U61	TSOP 50/Sn	1	1	1	0	1	0
U9	CLCC-SAC305	2	2	2	1	2	1
U10	CLCC-SAC305	1	1	1	2	1	2
U13	CLCC-SAC305	0	0	0	0	0	0
U14	CLCC-SAC305	0	0	0	0	0	0
U17	CLCC-SAC305	2	2	2	1	2	1
U22	CLCC-SAC305	1	1	1	2	1	2
U45	CLCC-SAC305	0	0	0	1	0	1
U46	CLCC-SAC305	1	1	1	0	1	0
U52	CLCC-SAC305	0	0	0	1	0	1
U53	CLCC-SAC305	1	1	1	0	1	0
U1	TQFP-144/Sn	2	2	2	1	2	1
U3	TQFP-144/Sn	0	0	0	0	0	0
U7	TQFP-144/Sn	1	1	1	2	1	2
U20	TQFP-144/Sn	0	0	0	0	0	0
U31	TQFP-144/Sn	2	2	2	1	2	1
U34	TQFP-144/Sn	1	1	1	2	1	2
U41	TQFP-144/Sn	0	0	0	1	0	1
U48	TQFP-144/Sn	1	1	1	0	1	0
U57	TQFP-144/Sn	0	0	0	1	0	1
U58	TQFP-144/Sn	1	1	1	0	1	0
U08	PDIP-20/NiPdAu	1	1	1	2	1	2
U49	PDIP-20/NiPdAu	1	1	1	2	1	2
U23	PDIP-20/NiPdAu	1	1	1	0	1	0
U30	PDIP-20/Sn	0	0	0	1	0	1
U38	PDIP-20/Sn	1	1	1	0	1	0
U11	PDIP-20/Sn	1	2	2	1	2	1
U51	PDIP-20/Sn	1	2	2	1	2	1
U59	PDIP-20/Sn	0	1	1	0	1	0
U15	QFN/Sn	2	2	2	1	2	1
U27	QFN/Sn	1	1	1	2	1	2
U28	QFN/Sn	2	2	2	1	2	1
U47	QFN/Sn	0	0	0	1	0	1
U54	QFN/Sn	1	1	1	0	1	0

NAVSEA Crane Rework Effort - Drop Test Vehicles

- The test vehicles are LF Manufactured Batch F; LF Reflow (SAC305) and Wave (SN100C) solder with LF profiles. All BGA components have SAC405 balls.
- Perform multiple pass rework 1 to 2 times on random Pb-free DIP, TQFP-144, TSOP-50, LCC and QFN components
- Test vehicles 80, 82, 87 were subjected to 10 drops at 340G and then 10 drops at 500G.
- Test vehicles 84, 85, 86 were subjected to 20 drops at 500G only. Based on initial results, all subsequent drop testing for the Crane and NASA-DoD test vehicles will be done at 500G only.

	PBGA 225					
	82	80	87	86	85	84
U18	12	17	15	10	2	6
U56	14	11	13	7	9	8
U55	19	11	19	7	6	3
U2	4	11	14	4	6	4
U4	10	11	6	3	2	4
U43	11	11	6	3	5	6
U21	8	8	10	5	5	3
U44	13	12	10	10	9	7
U5	5	7	5	4	3	2
U6	7	7	5	4	2	2

	CABGA 100					
	82	80	87	86	85	84
U32	0	0	0	0	0	0
U50	0	0	0	0	0	0
U33	0	0	0	0	0	0
U36	0	0	0	0	0	0
U19	0	0	0	0	0	0
U42	0	0	0	0	0	0
U37	0	0	0	0	0	0
U35	0	0	0	0	0	0
U63	0	0	0	0	0	0
U60	0	0	0	0	0	0

Number of Drops To Failure

NAVSEA Crane Rework Effort - Drop Test Vehicles

	CLCC 20					
	82	80	87	86	85	84
U9	0	0	0	0	0	0
U13	0	0	0	0	0	0
U14	0	0	0	0	0	3
U17	0	0	0	0	0	0
U45	0	0	0	0	0	0
U46	0	0	0	0	0	0
U22	0	0	0	0	0	0
U52	0	0	0	0	0	0
U53	0	0	0	0	0	0
U10	0	0	0	0	0	0

	TQFP 144					
	82	80	87	86	85	84
U1	0	0	0	0	0	0
U41	0	0	0	0	0	0
U3	0	0	0	0	0	0
U57	0	0	0	0	7	0
U58	0	0	0	0	0	0
U31	0	0	0	0	0	0
U20	0	0	0	0	0	0
U48	0	0	0	0	0	0
U7	0	0	0	0	0	0
U34	0	0	0	0	0	0

	TSOP 50					
	82	80	87	86	85	84
U26	0	0	0	0	0	0
U39	0	0	0	0	0	0
U40	0	0	0	0	0	0
U25	0	0	0	0	0	0
U12	0	0	0	0	0	0
U24	0	0	0	0	0	0
U61	0	0	0	0	0	0
U16	0	0	0	0	0	0
U62	0	0	0	0	0	0
U29	0	0	0	0	0	0

	PDIP 20					
	82	80	87	86	85	84
U11	0	0	0	0	0	0
U30	0	0	0	0	0	0
U38	0	0	0	0	0	0
U49	0	0	0	0	0	0
U51	0	0	0	0	0	0
U59	0	0	0	0	0	0
U8	0	0	0	0	17	0
U23	0	0	0	0	0	0

	QFN 20					
	82	80	87	86	85	84
U27	0	0	0	0	0	0
U15	0	0	0	18	0	0
U47	0	0	0	0	0	0
U54	0	0	0	0	0	0
U28	0	0	0	0	0	0

Number of Drops To Failure

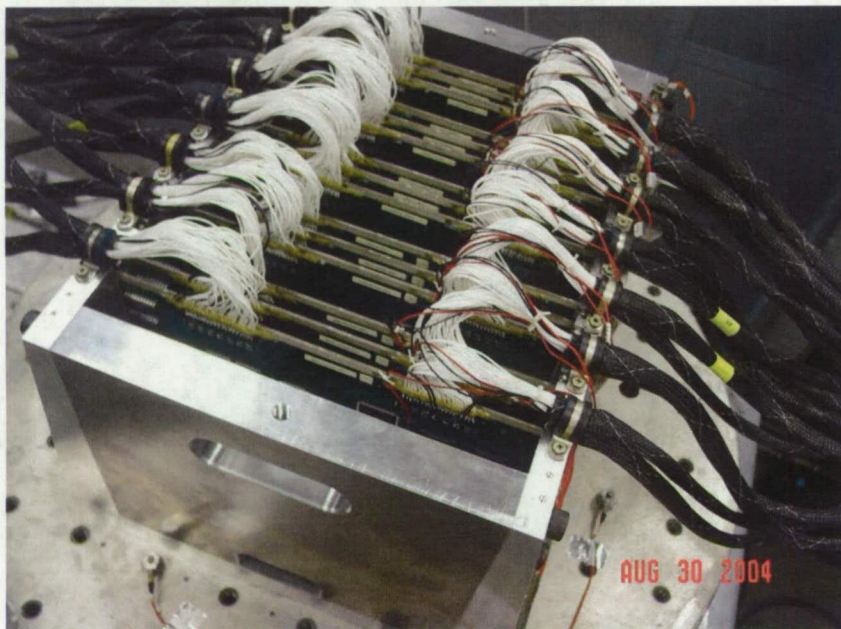
Thermal Cycle -55/+125°C

Parameters	- -55 to +125°C - Cycles: The project consortia will review the data and determine when the test is complete - Decision point at 2,000 and 4,000 cycles - 5 to 10°C/minute ramp - 30 minute high temperature dwell - 10 minute low temperature dwell						
							
	Number of Test Vehicles Required						
	Manufactured				Rework		
	Mfg. SnPb	Mfg. LF	Mfg. LF SN100C	Mfg. LF ENIG	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
	5	5	5	1	5	1	5
	Trials per Specimen		1				



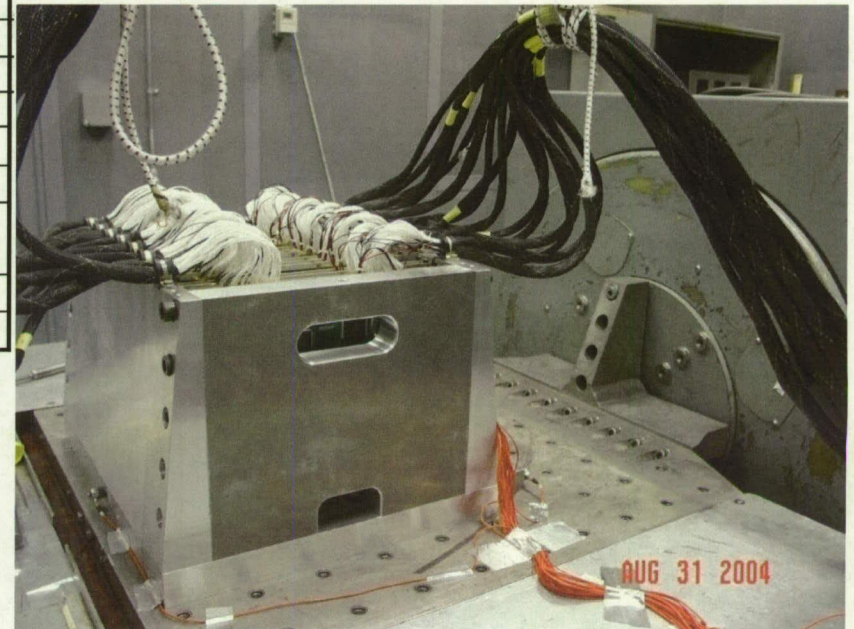
Vibration

Parameters	- Start at 8.0 g_{rms} then step up in 2 g_{rms} increments in the axis perpendicular to the plane of the test vehicles until the 20.0 g_{rms} level is completed. Vibrate for 1 hour at each test level. Finish with 1 hour at 28.0 g_{rms} .					
Number of Test Vehicles Required						
Manufactured				Rework		
Mfg. SnPb	Mfg. LF	Mfg. LF ENIG	Mfg. LF SN100C	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	1	5	5	1	5
Trials per Specimen			1			



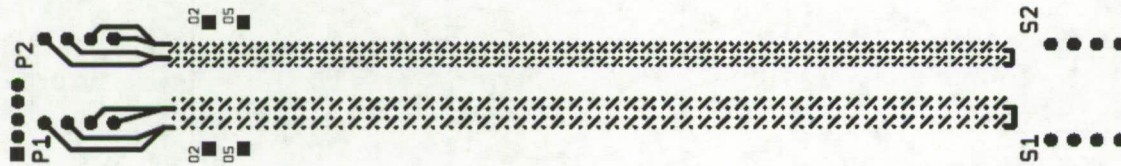
Mechanical Shock

Parameters	The shock transients will be applied perpendicular to the plane of the board and will be increased after every 100 shocks (i.e., a step stress test). Frequency range is 40 to 1000 Hz. SRS damping: 5%			
	Test Shock Response Spectra	Amplitude (G's)	Te (msec)	Shocks per Level
	Modified Functional Test for Flight Equipment (Level 1)	20	<30	100
	Modified Functional Test for Ground Equipment (Level 2)	40	<30	100
	Modified Crash Hazard Test for Ground Equipment (Level 3)	75	<30	100
	Level 4	100	<30	100
	Level 5	200	<30	100
	Level 6	300	<30	100
	Level 7	500	<30	100
	Level 8	700	<30	100
Number of Test Vehicles Required				
Manufactured		Rework		
Mfg. SnPb	Mfg. LF	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	5	1	5
Trials per Specimen		1		



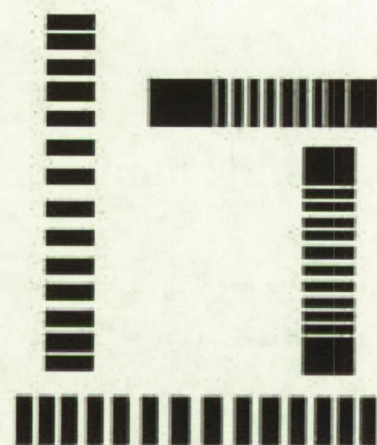
Interconnect Stress Test (IST)

- Accelerates thermal cycling testing by heating a specifically designed test coupon to 150°C (higher temperatures in specific applications in exactly 3 minutes followed by cooling to ambient in approximately two minutes.
- Assembly and rework simulation is achieved by subjecting the coupon to heating to 230°C (260°C for lead-free applications) in three minutes followed by cooling to ambient in approximately 2 minutes.
 - Three thermal cycles simulate assembly
 - Six thermal cycles simulate assembly and rework



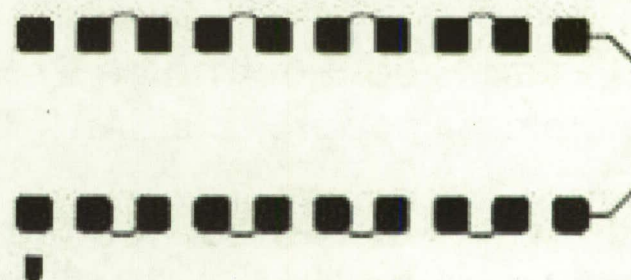
Copper Dissolution

Parameters	▪Mini-wave soldering versus manual soldering ▪Number of component removals, 1X versus 3X ▪FDIPS on break off coupon and QFP pad pattern ▪Metallographic Analysis: ▪As fabricated copper thickness ▪As assembled copper thickness ▪As reworked copper thickness				
Number of Test Vehicles Break off Coupons Required					
Manufactured			Rework		
Mfg. SnPb	Mfg. LF	Mfg. LF SN100C	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	5	5	1	5



U64

**Rockwell
Collins**



 **CELESTICA**

NASA-DoD Lead-Free Electronics Project

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Web Links:

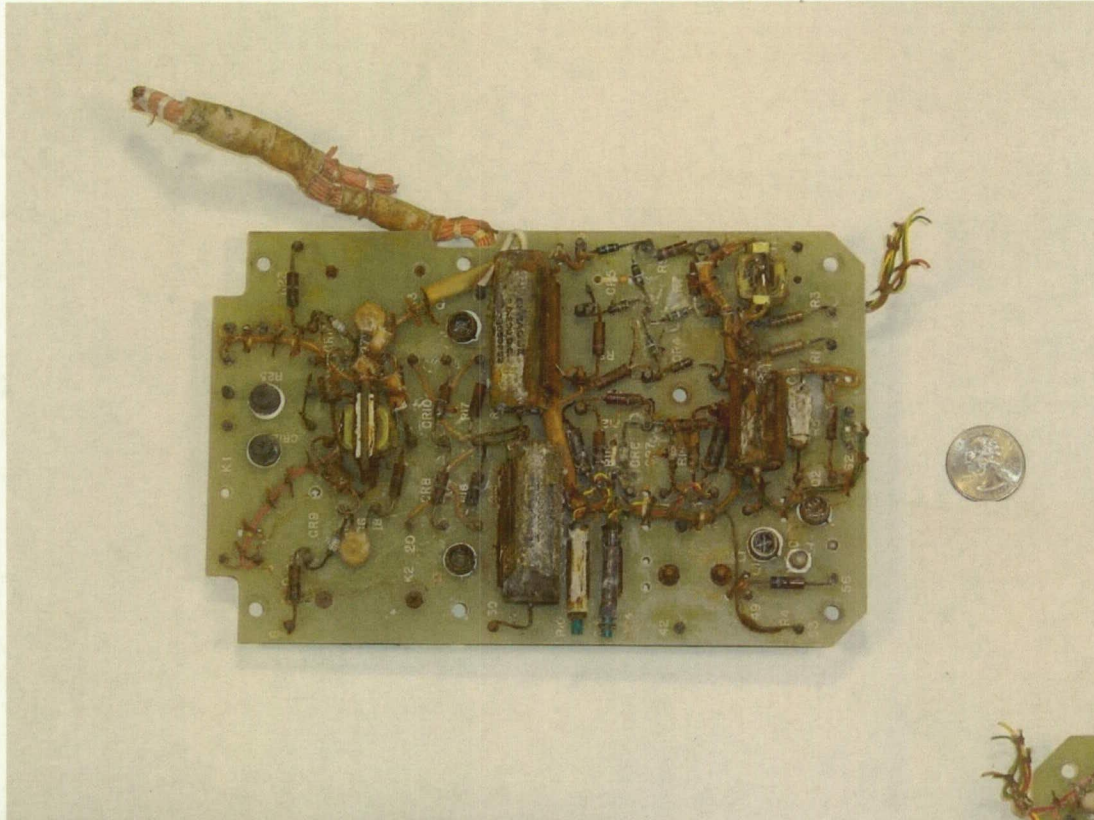
- **NASA-DoD Lead-Free Electronics Project:**

http://www.teerm.nasa.gov/projects/NASA_DODLeadFreeElectronics_Proj2.html

- **JCAA/JGPP Lead-Free Solder Testing for High Reliability:**

http://www.teerm.nasa.gov/projects/LeadFreeSolderTestingForHighReliability_Proj1.html

Questions



Hand wired circuit card retrieved from the Liberty Bell 7



The Liberty Bell 7 was pulled from a depth of 15,000 feet -- 3,000 feet deeper than the Titanic

